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ABSTRACT

This paper describes a computer-managed instruction (CMI) system used in teaching self-instructional modules in an educational media course covering communication theory, instructional design, media utilization, and production. The system is based on three underlying assumptions about the course: (1) the course consists of a set of discrete modules or topics, each containing units linked in some definable hierarchical structure: (2) tests consist of multiple choice items or questions to which the answer is a small integer number: and (3) once a student has chosen to study a particular unit, then the test for that unit must be passed before he may proceed to any other unit. The system was used by one section of students in the fall of 1977, refinements were made, and it was used with all sections in the fall semester of 1978 and 1979. Comments by students indicated that the majority were enthusiastic about the system for two reasons: using the terminal and the management system was an intrinsically interesting experience, and the system allowed students to assess their own performance and keep track of their own progress. (CHC)

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A CMI SYSTEM FOR A UNIVERSITY COURSE IN MEDIA

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Introduction

The individualization of content in many subject areas at university level is proceeding slowly but, nevertheless, surely. Invariably, the usual problems attendant upon such an enterprise are encountered: the need to develop a sufficient amount of courseware to meet student requirements, and the need to devise a management system which, for the most part, will be computer-based.

Not infrequently the latter problem takes on a special dimension at university level and, indeed, at the level of much adult learning. When relatively basic skills are to be learned, as in an elementary school, the modules or topics which are typically developed to provide individualized instruction may be arranged in a simple hierarchy which is, indeed, frequently linear. All learners are required to take all parts of the course, and individualization is mostly a matter of allowing for variations in rate of learning or, sometimes, the modality used. In many university courses, however, while parts of the subject matter are required, other parts may be optional. Further, the hierarchy of modules or topics may be far from linear.

These features exist in a university level media course for which parts have been individualized and provided with a computer management system.

The Media Course

As part of their teacher-training program at the University of Calgary, students may take courses in educational media. The first of these is an introductory course in which students receive instruction in communication

theory, instructional design, media utilization and production. Portions of this course, involving primarily the learning of utilization and production skills, are taught in a laboratory setting. The laboratory is open most of the time, and students "drop in" at their convenience to complete their assignments. Because of this, the laboratory portions of the course have always been "individualized" to the extent that students have worked on projects in their own time and at their own pace.

Recently, self-instructional modules for the laboratory portion of the course were developed with a grant from the Province of Alberta Ministry of Advanced Education and Manpower's Innovative Projects Fund. A module consists of a number of sub-units, each designed to teach a particular skill. For example, the photography module consists of units on camera techniques, composition, copystand, and so on, while units on thermofax, diazo and lift production techniques comprise the module on transparency production. The units consist of a mixture of media: slides with audio-tape, videotape, charts, checklists.

The modules provide instruction in both essential skills and options. In the photography module, for example, printing and film processing are options available to students interested in these areas. Within the module there is also some sequencing of units. Students have to take camera techniques first. But having completed this unit, it does not matter which of the other units they choose to work on next. In this way, maximum flexibility in catering to student interests is provided while assuring that all acquire certain basic competencies.

While flexible, self-instructional modularized instruction has a variety of pedagogical advantages, it creates organizational problems. It is unlikely

the structure of this course required additional facilities not normally found in such systems. Further, many systems operate only with a specific set of learning materials and have inherent features, such as requiring the students to follow a fixed linear path through the materials, which prevented their adoption for use with this course. Hence a new system centred around an entirely different algorithm was built.

The system allows the students to decide, within certain limits set by the instructor, the order in which they will complete the required units. They may also choose any of the optional units available.

Although it is general in the sense that it is not tied to any specific course content, the system is based on three underlying assumptions about the structure of the course.

The first of these is that the course consists of a set of discrete modules or topics, each containing units linked in some definable hierarchical structure. There can be up to approximately 20 units in a module, the exact number depending on both the size of real numbers the computer can store and the way in which the units are linked.

The hierarchical structure of each module is determined by the instructor. It may simply be linear as in many courses; or it may be convergent in the case where many skills are needed before a final one can be mastered; or it may be divergent where one skill is essential to the understanding of the other units in the module; or finally, it may be any combination of the other three types. See Figure 1.

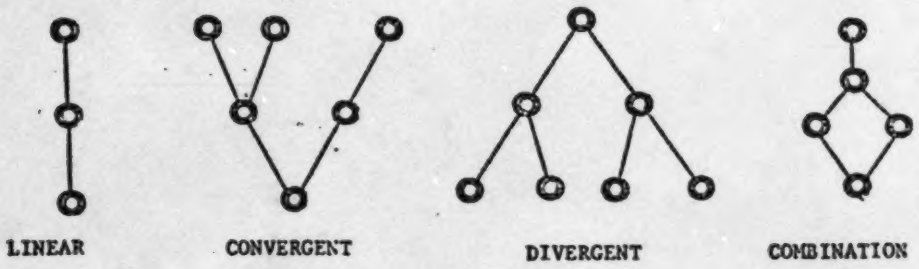

Figure 1

Any number of units may be optional. It is, however, incumbent upon the instructor to devise a valid hierarchy as the computer programs do not check for hierarchies in which required units have optional prerequisites.

An example of a valid hierarchy is the photography module of the course. This follows a simple divergent pattern and has two optional units. See Figure 2.

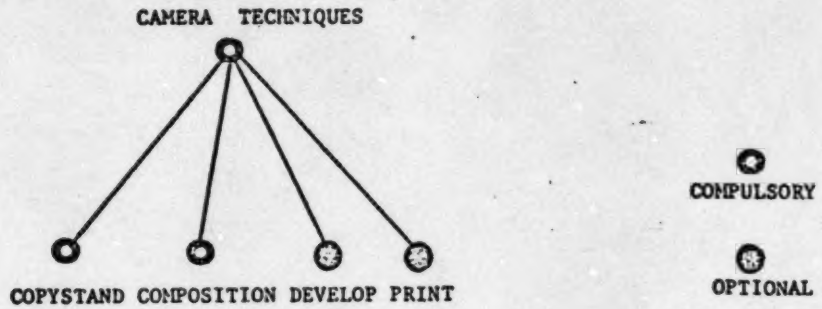

Figure 2

Here the instructor has determined that the information in the camera techniques unit is needed in the other four units and it must, therefore, be completed first. After this there are four units from which the student may make a choice. The only requirement is that the copystand and composition units are successfully completed before the student may take any units from the next module. Even in this relatively simple structure there are 38 different paths available. Hence the management system,

although controlling the overall direction of the course, allows students not only to take different paths through the learning materials but also to cover more material in those modules in which they have a particular interest or aptitude.

The first task for an instructor wishing to use the system is to enter the hierarchical structure of each module. Each one may have a different configuration. For each unit the module number, unit number, and name are first entered. These are followed by data describing the position of the unit in the hierarchy and its relationship to units already entered if it is directly linked to any of these. Finally, the instructor enters the number of questions to be given in the test, the percentage of correct answers for passing the test, and information on whether or not the unit is optional.

The hierarchical description is entered on-line in response to prompts and is stored in the hierarchy file. Editing features exist which allow the instructor to add or delete units in a module or change the test parameters at any time except when students are registered and active on the course. The system automatically adjusts the links within the new configuration and makes some checks in an attempt to ensure that the structure remains valid. These checks, however, cannot cover all contingencies and the final responsibility for valid hierarchical structure rests with the instructor.

When the information on the structures of the different modules is entered through the terminal it is stored in a data file. As the units are entered they are numbered sequentially and also assigned a prime number. For

example, the third unit entered is unit 3 and it is assigned the third prime number 5. Then the links of the hierarchy can each be uniquely defined in terms understandable to the computer by a product of prime numbers.

This is illustrated in Figure 3, which shows the portion of the hierarchy file for the photography module. The ten colums are the unit name, its module number, the prime number of the module, the unit number, the prime number of the unit, the number of questions in the test bank, the number of questions to be given in a test, the mastery level as a percentage, an indicator showing whether the unit is optional, and the pre-requisite units stored as a product of their prime numbers.

The photography module has a simple divergent structure. The unit on camera techniques has no pre-requisites and its prime product is therefore 1; the other four units have camera techniques as a pre-requisite and their prime product location is 2, the unit prime of camera techniques.

Camera techniques	3	5	1	2	27	10	80	1	1
Copystand	3	5	2	3	32	10	80	1	2
Composition	3	5	3	5	28	10	70	1	2
Developing	3	5	4	7	22	10	70	2	2
Printing	3	5	5	11	15	10	70	2	2

Figure 3

The second assumption is that the tests consist of multiple choice items or questions to which the answer is a small integer number.

Once the hierarchies are built the instructor can enter banks of test questions for each unit. There is no restriction on the length of a question nor on the number of questions for a unit, except that the latter must be at least equal to the number of questions to be given in the test for that unit. Again, editing features exist which allow the addition or deletion of questions, or changes to existing items, at any time. Also, listings of all or part of a unit's test questions may be obtained by the instructor. These question banks are stored in ASCII files with a separate file for each unit. The whole file is automatically deleted when the corresponding unit is deleted from the hierarchy.

At the beginning of each semester the IDs and names of the students are entered. A student may then start by taking a test on a fixed unit. Each student's test will probably be different since the required number of questions for a test are chosen randomly from the bank. The more questions there are in the bank, the greater will be the difference between the tests given.

If the test is failed the student is required to take another test on the same unit. This is the third assumption: once a student has chosen to study a particular unit, then the test for that unit must be passed before he may proceed to any other unit. The questions in any repeated tests will most likely be a combination of items previously presented and new items, because each test is chosen in the same manner, randomly without replacement from the entire bank.

On successful completion of a test a student receives a list of all the units which can be studied next. This list of choices is governed by the

hierarchy and by the units which have already been completed. These latter data are kept in the student record as a product of the units' prime numbers and are sufficient, in conjunction with the units' prime numbers and their product of primes describing the pre-requisites, to determine the precise choices available to a student at any time.

The program simply needs to make two decisions based on these numbers for each unit in the module. These are first, whether the unit has been completed or not, and secondly, if it has not, whether the student has the pre-requisites for it. The former is determined by dividing the prime product in the student record by the prime of the unit, and the latter by dividing the prime product in the student record by the prime product of the unit.

For example, for the structure shown in Figure 4, if the student had completed units 1 and 3 the prime product in his record would be 10 (2 x 5). Dividing this number by the prime of each unit in turn (2, 3, 5, 7, 11) would disclose that units 2, 4 and 5 might be possible choices. On the check for the pre-requisites, however, 10 would be divided in turn by 2, 6 and 6 indicating that only unit 2 is available to the student.

On the other hand, if units 1 and 2 had been completed, then the prime product in the student record would be 6 (2 x 3). In this case the first check would show units 3, 4 and 5 as possible choices, and the second set of divisions (6 divided in turn by 2, 6 and 5) would not eliminate any on the original list. Hence the student would be given a list of the three units from which to make a choice.

When such a list for a module consists only of optional units, those units with no pre-requisites from the next module are added to the list.

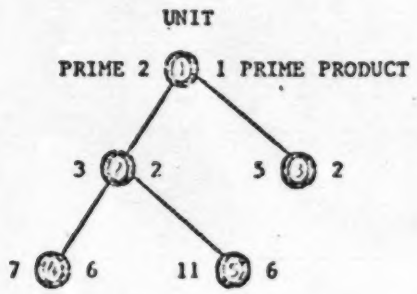

Figure 4

Various reports are available to the instructor. These include summary lists such as names and IDs; and names, IDs and grades. They may be obtained for all students registered on the system, or for a sub-group of these, or for an individual student.

A more detailed report is also obtainable which gives complete information for each test taken. This lists the module number, unit, each question selected randomly from the bank and the answer chosen, and the number answered correctly. Again this report is available for all students, a group or an individual. Because of its comprehensiveness, it is best used in the latter case to determine a student's problems.

In addition to these summary and detailed lists on the performance of a group or an individual student, the instructor may at any time request information on the bank of test questions for a particular unit. This provides such data as the number of students passing the test at their first attempt, the number of students repeating the test, the total number of

repeated administrations, the average mark obtained and an analysis of answers given for each question in the bank. The summary table shows for each question the number of times it has been presented, the number of times each choice has been selected, and the correct answer. This information allows the instructor to identify those questions which are too difficult or too easy and often to discover deficiencies in the instructional materials.

For example, an early set of data from the photography module gave the following:

Composition

Total number of questions on file	28
Number of questions for test	10
Percentage correct for pass	70
Passed at first attempt	20
Number of students repeating	8
Total number of repeats	23
Average mark	6.51

Q	TP	1	2	3	4	5	CA
1	17	0	15	0	2	0	2
2	16	8	3	0	5	0	4*
3	22	2	13	5	2	0	2
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25	17	1	0	14	2	0	3
26	15	5	0	0	10	0	1*
27	15	14	0	0	1	0	1
28	21	11	4	1	3	0	1

In addition to providing information about the test for the unit, and the general success of the students taking it, the information on each question permits item analysis to be performed. Further, it indicates to the instructor where the instructional materials are not as effective as they might be. Questions two and twenty-six above indicate problems. The correct answer for question two is 4. However, most of the students gave 1 as their answer. The question asked students to select pairs of qualities best describing a good photograph. Choice 1 was "focussing and framing"; choice 4, the correct answer, was "harmony and variety." It was clear that the students were thinking primarily in terms of technical rather than aesthetic criteria for a good photograph. The instruction was modified to de-emphasize the technical criteria.

A more recent set of data gave the following for question 2:

Q	TP	1	2	3	4	5	CA
2	24	6	2	1	15	0	4

The problem appears to have been solved. However, the more recent data for question 26 are:

Q	TP	1	2	3	4	5	CA
26	21	8	1	1	11	0	1

Here, further revision is still obviously needed.

Results

Starting in the fall of 1977, the system was used with one section of students (approximately forty in number), after which further refinements were made to the tests, and two more units were added to the photography module. In

the fall of 1978 and 1979, the system was used with all sections of the course.

So far, only one student has not succeeded in completing the necessary units with their accompanying tests. However, not all passed the first time. The photography module is again a case in point (1979 data, compulsory units):

Unit	Camera Tech.	Copy-stand	Composi-tion
Passed first time	27	15	39
Students repeating	27	39	15
Average mark	7.59	7.47	7.48

With the exception of composition, half or more of the students failed the test on the first occasion. (The pass mark for camera techniques and copystand was 80%. For the other unit it was 70%). Inspection of scores for individual students showed that very few had to repeat the test more than three times, with most passing on the first or second attempt. A student failing a test was directed to see the instructor in order to determine the area of difficulty before repeating the test.

Written comments collected from students showed that the majority were enthusiastic about the system for two main reasons. The first was that using the terminal and the management system was an intrinsically interesting experience. Few of the students in the course had used a terminal previously and they found the experience fascinating and informative, especially, as several pointed out, in a course on educational technology. The second reason was that the system allowed students to assess their own performance and keep track of their own progress. In the fall semester, 1978, the laboratory portion of the course was tested as part of the final examination. Students found the testing portion of the management system useful for reviewing this examination.

A minority of students have not liked using the management system. Reasons given include unfamiliarity with computers, the amount of time taken to complete the test and, until the fall of 1979, the absence of information on the right answers after questions are completed. This last criticism has been addressed. The correct answer is now given after a student answers the question.

It is interesting that, on the three occasions that the system has been used with the course, student opinions about it have been polarized. Students are either very enthusiastic, or quite negative, with few taking a middle-of-the-road position. It appears that, as yet, not all students are sufficiently at ease when using a computer terminal.

For the instructor the results of using the system so far have generally been encouraging. Student data have permitted both revisions to the tests and to the instructional units. The problems that the students encountered with the system were readily correctable. A set of instructions on its use has been produced, to minimize student difficulties. The system, and the modules it manages, are now sufficiently proven to warrant further development.

The rest of the laboratory component is to be brought under the management system, and modules are to be developed for the more theoretical portions of the course. It is the intention that, eventually, most of this course will be modularized and individualized; and it is considered that, with a proven computer management system, this is now feasible.

The management system has also been implemented in a university level music course, and plans are being made to extend its use into other courses in

the University. Experience to date suggests that this is the type of system needed for many courses offered to mature learners, and that it may without too many extensions be generalized for use in a variety of learning environments.